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Greier et al.

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[54] **DECOMPRESSION DEVICE IN AN INTERNAL COMBUSTION ENGINE**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[3] **F01L 13/08**

[52] **U.S. Cl.** **123/182;** 123/90.16

[58] **Field of Search** 123/182, 90.16; 417/298

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Attorney, Agent, or Firm—Watson, Cole, Grindle & Watson

[57] **ABSTRACT**

A controllable operating spindle includes a decompression cam mounted thereon, which cam is able to keep a valve actuation-movement transmitting element in a position which is spaced away from the position determined by a base circle of a cam on the engine camshaft. A ratchet wheel is connected to the operating spindle which extends along the length of and parallel to the engine camshaft and is adapted to co-act with a trip element for restoring the decompression cam to its original position. The operating spindle includes at least one decompression cam for each cylinder of the engine and between the decompression cam and the valve actuation-movement transmitting element there is provided a decompression lever which influences the transmitting element in accordance with the lift of the decompression cam.

5 Claims, 8 Drawing Figures

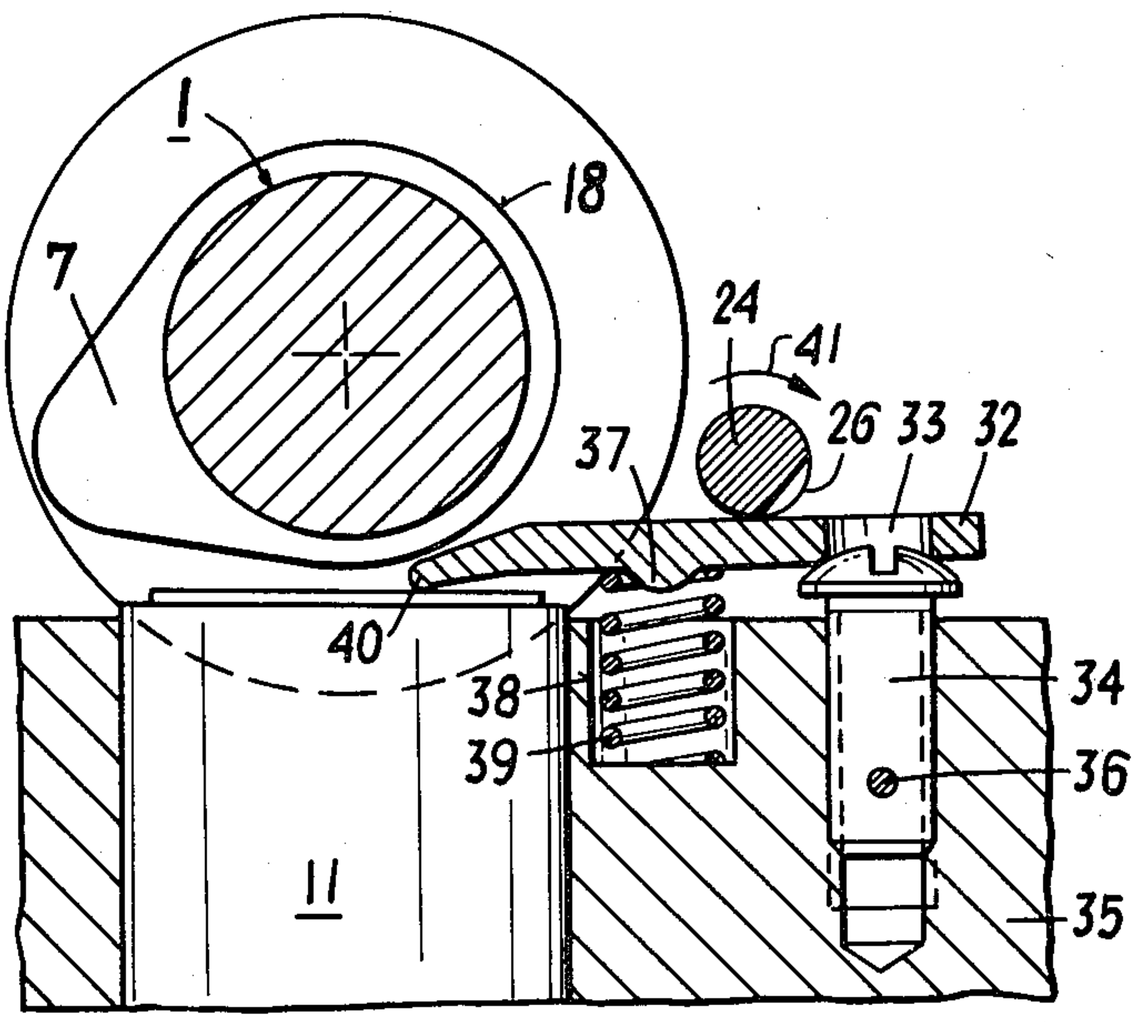
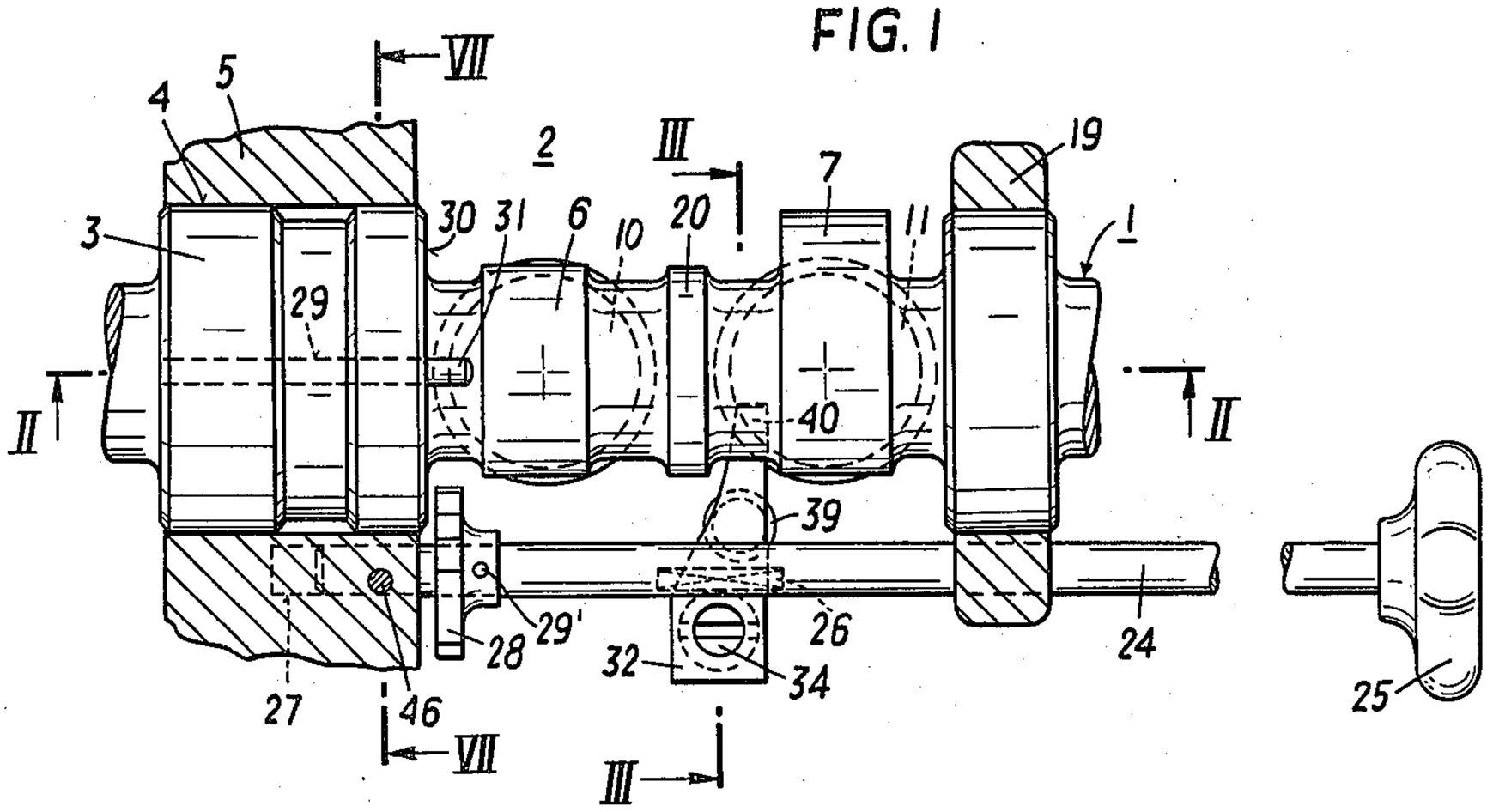


FIG. 1


VII
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5
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III
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3
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26
24
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VII
III

FIG. 2

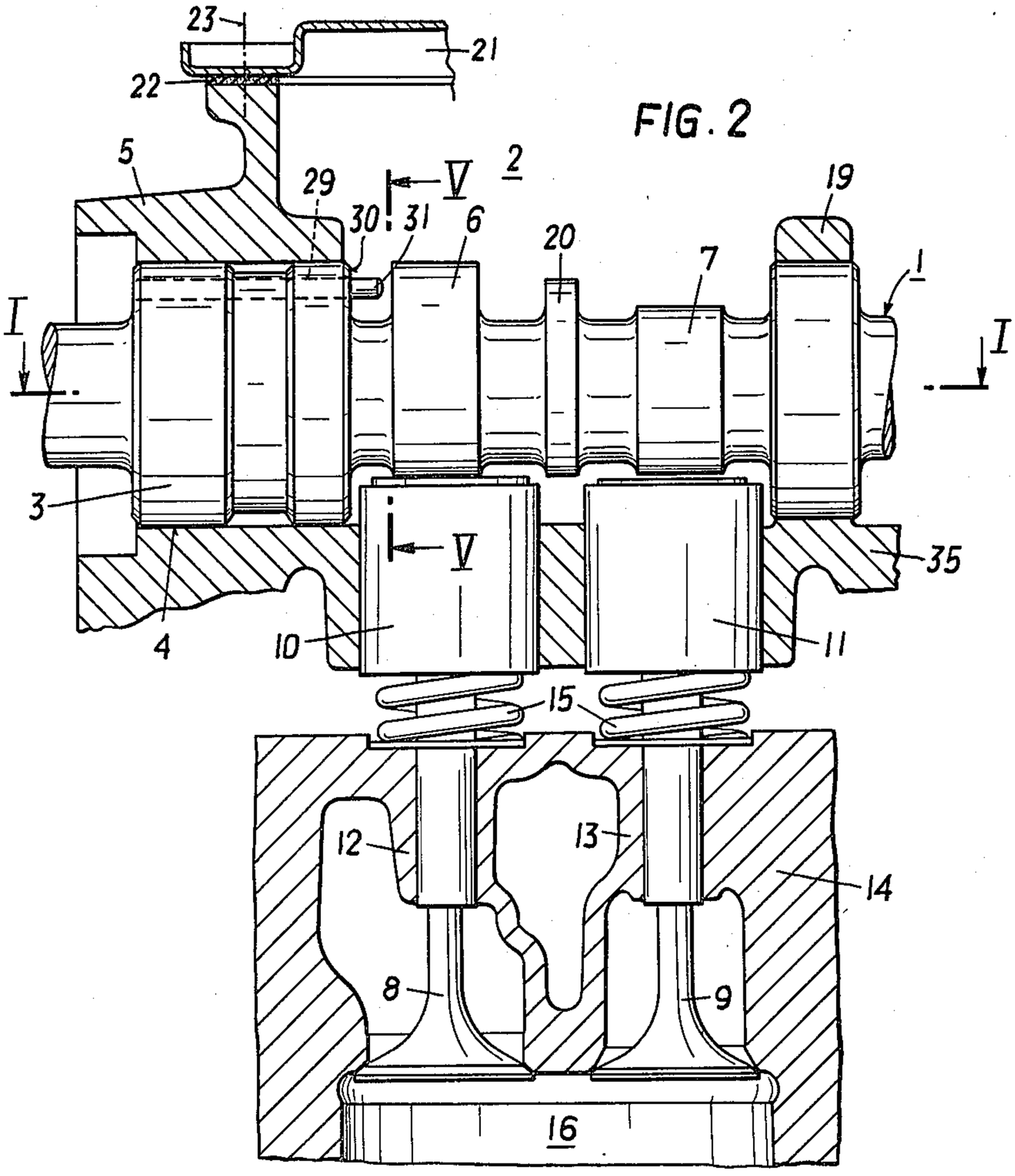
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FIG. 3

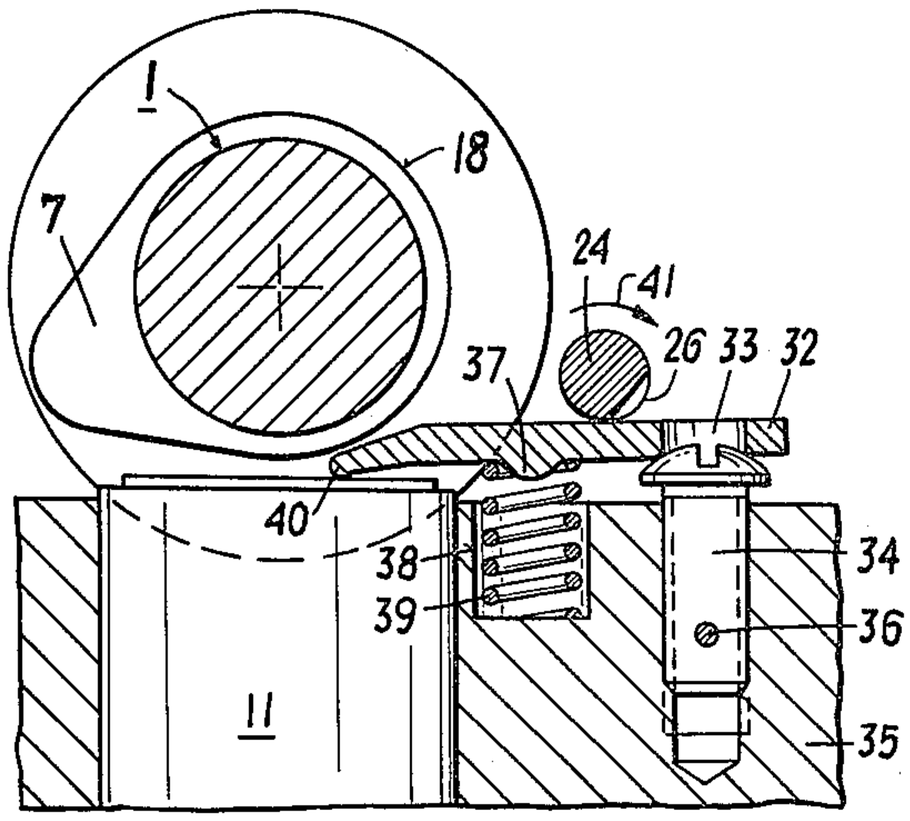


FIG. 4

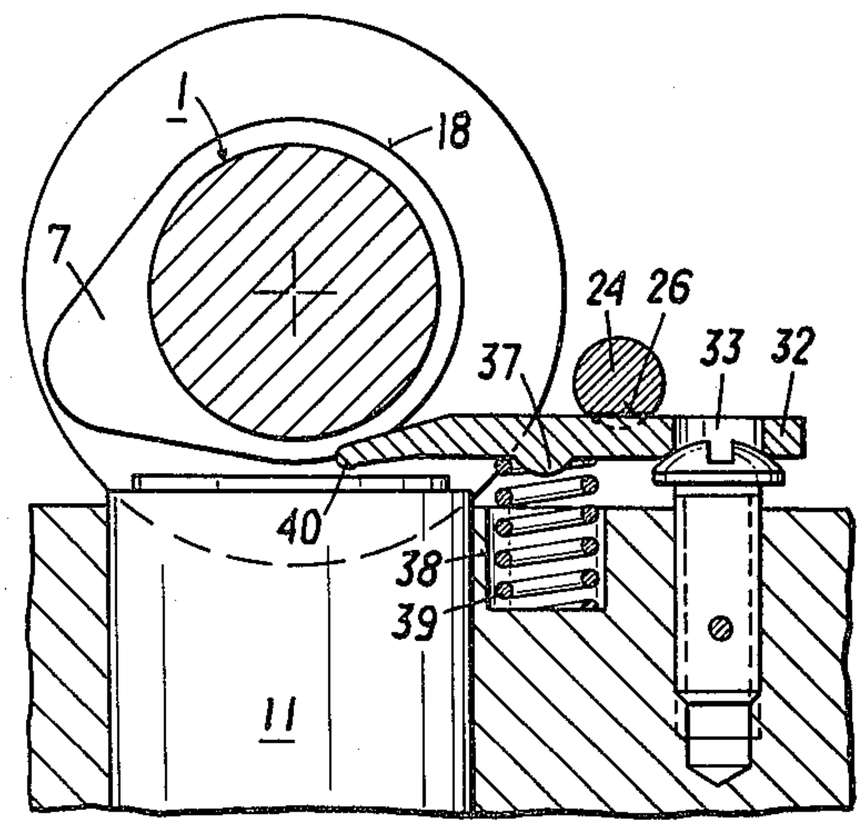


FIG. 5

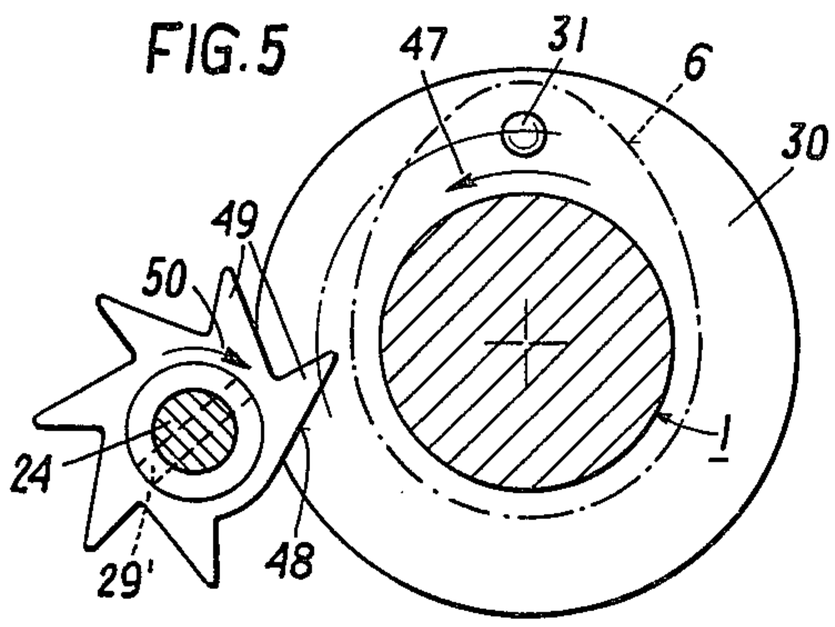


FIG. 6

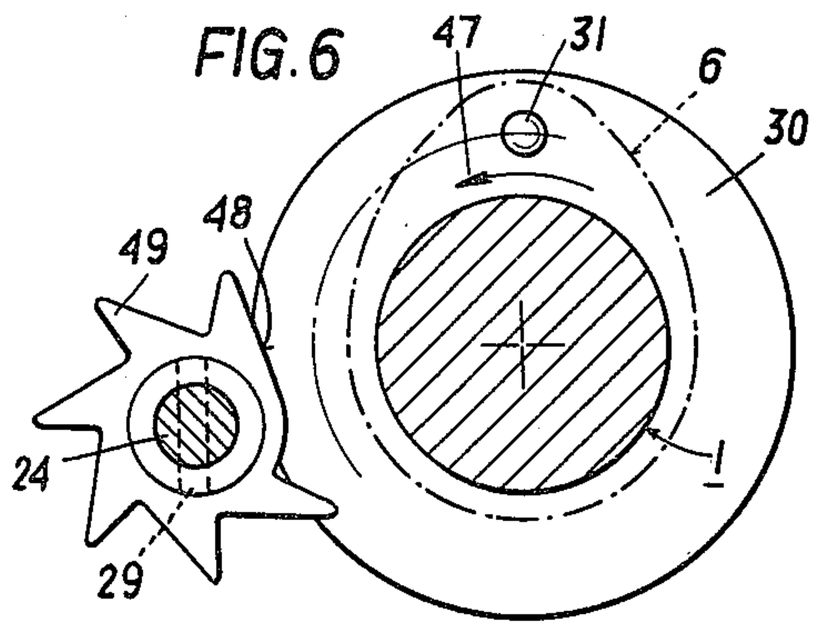


FIG. 7

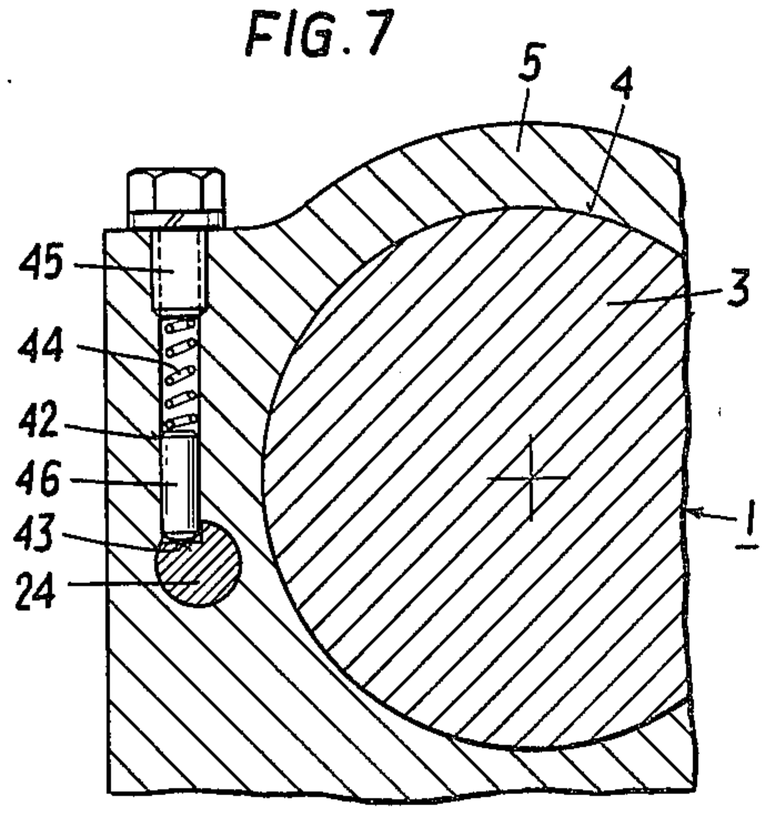
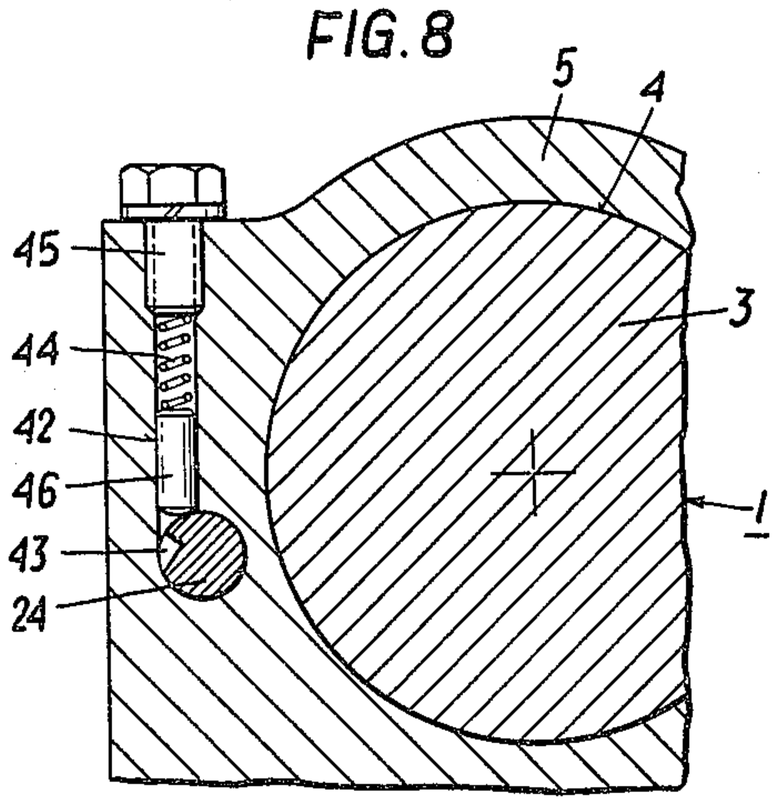


FIG. 8



DECOMPRESSION DEVICE IN AN INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

The present invention relates to a decompression device in internal combustion engines of the kind comprising a decompression cam or like element mounted on a controllable operating spindle for actuating a valve which is to be influenced by the decompression device. The decompression cam keeps an element, for example, a cam follower, which transmits the operative lift of the camshaft cam to the valve, in a decompression position wherein it is spaced away from the position which is determined by the base circle of the cam on the camshaft of the engine. A ratchet wheel is connected to the operating spindle, which extends along the length of and parallel to the engine camshaft and is adapted to co-act with a trip element for restoring the decompression cam to its original position.

DESCRIPTION OF THE PRIOR ART

A decompression device of the abovementioned kind, which is known from German Laid Out Print No. 2 019 755, is designed for application to the internal combustion engines of the kind in which the valves are actuated by rocker arms. This decompression device comprises a control handle which extends laterally out of the valve chamber. The cam is formed as an eccentric and the hub of one rocker arm is rotatably mounted thereon. The displacement of this rocker arm hub which was mounted on the eccentric is obtained by means of a peripherally toothed driver-plate on which the teeth extend all round the circumference of the plate except for a single tooth gap. Thus it is left to the discretion of the user to decide on the length of the decompression time, and this could occasionally result in maladjustment.

Another form of a decompression device is shown in German Laid Open Print No. 2 242 206. This decompression device is also designed for application in internal combustion engines having valve rocker arms. However, in this arrangement no operting spindle is provided for co-operation with an actuating element, but instead there is provided a friction brake mechanism in the form of two rubber rings which cause a timedelay in the restoration from a decompression to an operative position of the locking element which is applied to the valve mechanism and which prevents the full closing of the valve. This device has a highly complicated construction and also a tendency to malfunction.

Lastly, German Pat. No. 698 244 describes a decompression device for a single-cylinder internal combustion engine in which the exhaust valve is actuated through a pushrod and guiding arm by the cam of the camshaft. The guiding arm is mounted for pivotal movement about a pin which is secured in the housing. A decompression spindle is rotatably mounted parallel to the camshaft and adapted to be rotated by means of a manual control lever which extends out of the valve chamber. The decompression spindle carries a cam and by rotating this cam the exhaust valve can be lifted into a decompression position. Restoration of the exhaust valve is effected by a Maltese-cross transmission system. This known decompression device has the drawback of being virtually unusable in internal combustion engines in which the valves are actuated directly by the camshaft without transmission links or rocker arms, besides which it cannot be used in multi-cylinder engines.

SUMMARY OF THE INVENTION

It is an object of the present invention to eliminate the drawback appertaining to the known devices and to provide a decompression device of the kind specified from the outset which can also be used in internal combustion engines not having rocker arms, which, furthermore, can be fitted in a particularly space-saving manner and which can be re-set very easily or adjusted in case of cam wear. Moreover, the duration or length of time of the decompression process is not to be left to the arbitary choice of the user but instead the decompression device is arranged to be cut out early, after only a few operative cycles whereafter the engine assumes its normal mode of operation.

According to the present invention these aims are achieved primarily due to the fact that the operating spindle comprises at least one decompression cam for each cylinder and that between the decompression cam and the transmission element for valve actuation, for example, the cam follower, there is provided a decompression lever which influences the transmission element in accordance with the lift of the decompression cam.

According to a further development of the present invention the decompression lever is articulately mounted on a vertically adjustable bearing and applied to the decompression cam under spring loading. Due to the vertically adjustable mounting of the decompression lever, which transmits the lift of the decompression cam to the valve-actuation transmission element and thus to the respectively associated valve, it is very easy to adjust the decompression device individually for each cylinder, that is to say for each valve which is to be actuated, and thus compensate for differential amounts of clearance and/or different manufacturing and fitting tolerances. Due to the provision of a spring which maintains the decompression lever constantly applied to the decompression cam, shock loads are very largely avoided in respect of the various component parts of the decompression device and vertical adjustment of the decompression lever is simplified.

If the decompression device—which is also suitable for application in single-cylinder engines—is applied to multi-cylinder internal combustion engines it is particularly advantageous if, in further development of this invention, the operating spindle is provided with intermediate bearings supporting it between the individual cylinders. This prevents undue deflection of the operating spindle which during the decompression process is at least periodically subjected to the full force of the valve spring, and also allows a spindle of smaller diameter to be fitted than would otherwise be necessary.

According to another feature of this invention a ratchet wheel may be arranged in the vicinity of one of the end bearings of the operating spindle. Such an arrangement particularly simplifies the mounting of a pawl which rotates eccentrically with the camshaft. The sudden shock load, which is applied to the spindle by the operative engagement of the pawl with the ratchet wheel on each camshaft revolution for the duration of the decompression process, is transferred in this arrangement to a region which is supported by the bearings of the operating spindle. Moreover, owing to the outer camshaft bearing which is usually provided in the same region there is a relatively large amount of

available space for the restoring mechanism of the decompression device which means that the ratchet wheel may be of relatively large dimensions thus reducing wear and increasing useful service life.

According to another feature of the present invention a spring-loaded pin is arranged on one of the spindle bearings which pin engages a recess on the spindle when the latter occupies a position corresponding to commencement of the decompression process. The recess and the pin are designed in such a way that during restoration by the ratchet wheel the pin yields against the spring loading force and becomes non-effective. This provides an end stop for the spindle rotation which initiates the decompression process, thus allowing full utilization of the number of camshaft revolutions executed during the decompression process, which number depends on the number of teeth on the ratchet wheel. Moreover, this arrangement avoids the application of excessive stresses to ratchet wheel and pawl element in as much as it precludes the risk of the pawl element, which revolves with the camshaft, striking against a tooth crest of the ratchet wheel if the latter should happen to be in a non-aligned or intermediate position. This provides a considerable improvement in operational safety of the decompression device.

DESCRIPTION OF THE DRAWINGS

The present invention is hereinafter more particularly described with reference to an embodiment illustrated by way of example in the accompanying drawings, wherein:

FIG. **1** shows a part-sectional view along line I—I in FIG. **2**, of an internal combustion engine fitted with a decompression device according to this invention,

FIG. **2** shows a partial sectional view along line II—II in FIG. **1**,

FIGS. **3** and **4** show in each case a partial sectional view along line III—III in FIG. **1**, but with the decompression device in relatively different operative conditions,

FIGS. **5** and **6** show partial sectional views along line V—V in FIG. **2** of the device in the operative conditions respectively corresponding to FIGS. **3** and **4**, and

FIGS. **7** and **8** show partial sectional views along line VII—VII in FIG. **1**, again reflecting operative conditions respectively corresponding to FIGS. **3** and **4**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The camshaft **1** of an internal combustion engine (not specifically shown) is arranged in a camshaft chamber **2**, and mounted at one end **3** thereof in a journal-bearing in a bore **4** in a wall **5** of the camshaft chamber **2**. The camshaft **1** is driven, in a manner not specifically illustrated, by a crankshaft of the internal combustion engine and comprises cams **6** and **7** which in the illustrated embodiment directly actuate two valves **8** and **9** via cam-follower cups **10** and **11**. The valves **8** and **9** are guided in bosses **12, 13** of the cylinderhead **14** and, being loaded by the force in valve springs **15**, seal off the combustion chamber **16** for as long as the cam follower cups **10, 11** seat on the base circle **18** (FIGS. **3,4**) of the cams.

The camshaft **1** is supported by intermediate bearings **19** between the individual cylinders of the engine and is provided, for each cylinder, with a further cam **20** arranged between the cams **6, 7** which actuate the valves **8, 9**, which further cam **20** controls a fuel injection pump (not shown). The camshaft chamber **2** is made oiltight relative to the exterior by a cover **21**, interposed seal **22** and bolts which are only indicated by their center line **23**.

An operating spindle **24**, which is adapted to be rotated by a hand wheel **25** mounted thereon externally of the engine case, and which is mounted parallel to the camshaft **1** in the wall **5** of the camshaft chamber **2** and in the intermediate bearings **19** between the individual cylinders, is provided, for each cylinder of the engine or for each valve which is to be actuated by the decompression device, with a decompression cam **26** which is formed by providing a flat face on the cylindrical peripheral surface of the operating spindle **24**. Adjacent to an end bearing **27** for the operating spindle **24** a ratchet wheel **28** is secured on the spindle by means of a pin **29'**. The ratchet wheel **28** co-acts with a trip pin **31** arranged in a bore **29** formed in end **3** of the camshaft **1** and which protrudes from a shoulder **30** of the camshaft. This trip pin **31** revolves eccentrically with the camshaft **1** and, as will be seen from FIGS. **2** and **6**, is so arranged in the shoulder **30** that, as viewed in the direction of the camshaft axis, it is within the contour of cam **6** so that, despite the very compact and close assembly, the trip pin **31** cannot strike against the cam follower cup **10**.

In the range of the decompression cam **26**, that is to say, in the region of the valve **9** which is to be actuated by the decompression device, there is a decompression lever **32** which transmits the lift of decompression cam **26** to the cam follower cup **11** which actuates valve **9**. That end of the decompression lever **32** which is opposite the cam follower **11** is provided with a bore **33** by which it sits on a fillister-head screw **34**. This screw **34** is screwed into a threaded hole in the bottom base **35** of the camshaft chamber **2** and made resistant to rotation by a plastic pin **36** inserted in its threaded shank and bearing against the threaded bore. Thus a vertically adjustable support is provided for the articulated mounting of the decompression lever **32**. On the opposite end to the bore **33** in relation to the operating spindle **24**, the decompression lever **32** is provided with a nodule **37** which centers a spring **39** fitted in a bore **38** in the base **35** of the camshaft chamber **2**. This spring **39** applies the decompression lever **32** to the decompression cam **26** on operating spindle **24** and to the bearing surface provided by the fillister-head screw **34** and thus prevents relative play between these parts. The end **40** of the decompression lever **32** which is opposite the bore **33** is adapted to co-act with the cam follower cup **11**.

The mode of operation of the decompression device according to this invention is more particularly described as follows. FIGS. **4, 6** and **8** show the device in the disengaged position, that is to say when the engine has been stopped or when it has been running for some time, and FIGS. **3, 5** and **7** show the device at the point when the decompression process has just begun.

To initiate decompression with the engine stationary, the operating spindle **24** is turned by handwheel **25** in the direction of arrow **41** (FIG. **3**) so that the flat face of the decompression cam **26** on the spindle **24** is disengaged from the decompression lever **32** and the latter, under the opposing force produced by the cylindrical surface of the cam **26** displaces the cam follower **11** against the force of the spring **39** in the direction of opening the associated valve **9** by a distance which is determined by the lift of the decompression cam **26**. This initial rotation of the spindle **24** is limited by a stop

arranged on end bearing **27** whereby the initial operative condition of the decompression device is established which is represented in FIGS. **3, 5** and **7**. According to FIG. **7** the stop for the operating spindle **24** is provided by a pin **46** guided in a bore **42** of end bearing **27** and engaging a recess **43** formed in the circumferential surface of the operating spindle. The pin **46** is loaded by a spring **44** which is also contained in the bore **42** and pretensioned by a screw **45**. The recess **43** in the spindle **24** and the pin **46** are so designed that the pin **46** moves against the action of spring **44** during the restoration of the spindle by means of the ratchet wheel **28** subsequently described.

The end **40** of decompression lever **32**, now depressed by the cylindrical part of the decompression cam **26**, has lifted the cam follower cup **11** away from the position which is determined by the base circle **18** of cam **7** on camshaft **1**, so that the associated valve **9** can no longer close completely and normal compression is prevented in the combustion space **16**. In the position of ratchet wheel **28** shown in FIG. **6**, when the operating spindle **24** occupies the position shown in FIG. **4**, a tooth gap **48** allows unobstructed rotation of the trip pin **31** mounted in shoulder **30** of camshaft **1**. When the spindle **24** is turned into the position represented in FIG. **3** the position of the ratchet wheel **28** changes to that shown in FIG. **5**.

During the starting up of the internal combustion engine which is assisted by the actuation of the decompression device, each revolution of camshaft **1** in the direction of arrow **47** (FIG. **5**) brings the trip pin **31** successively into engagement with one of the teeth **49** of the ratchet wheel **28**. Thus the operating spindle **24** and hence the decompression cam **26** are turned back on each revolution of camshaft **1** in the direction of arrow **50** through an angle which depends on the tooth pitch of the ratchet wheel **28**, until the tooth gap **48** once more allows unobstructed rotation of the trip pin **31**. At this point the decompression process is completed, which means in particular that the cam follower **11** drops back onto the base circle **18** of cam **7** and the condition which is depicted in FIGS. **4, 6** and **8** has been restored. In the illustrated embodiment the decompression process is thus completed after six camshaft revolutions which is perfectly adequate for easy starting of the engine.

Adjustment of the decompression device for each individual cylinder, which is particularly important in multi-cylinder engines can be very easily obtained by means of the fillister-head screw **34** which supports the decompression lever **32**, namely by adjusting the screw **34** to such a height that the end **40** of lever **32** does not prevent the complete closure of the associated valve **9** in normal engine operation whilst on the other hand there is no significant play between the lever end **40** and the cam follower **11** which could impair the effect of the decompression cam.

The arrangement according to this invention which, as has been hereinbefore described in respect of the illustrated embodiment, affords special advantages in its application to multi-cylinder internal combustion engines is however equally well adapted for application to single-cylinder engines, a special advantage arising from the fact that for the correct functioning of the device according to this invention it is quite immaterial what type of valve actuation mechanism may be provided in the engine.

We claim:

1. A decompression device for an internal combustion engine having at least one cylinder, at least one valve, and a camshaft including at least one cam having a base circle cam surface, said decompression device comprising:

a controllable operating spindle mounted on said engine and extending along the length of and parallel to said camshaft;

at least one decompression cam disposed on said operating spindle and provided for each said at least one cylinder;

a follower element for transmitting an operative lift of said camshaft cam to said valve;

a ratchet wheel connected to said spindle;

a trip element coacting with said ratchet wheel for restoring said decompression cam to an original position;

a decompression lever having one end for contacting said follower element and being articulately disposed between said decompression cam and said follower element;

a vertically adjustable bearing contacting the other end of said decompression lever; and

spring means for articulately mounting said decompression lever on said adjustable bearing and for applying said decompression lever to said decompression cam under spring loading, said at least one decompression cam being controllable to cause said decompression lever to selectively maintain said follower element in a decompression position with said follower element being spaced apart from said base circle cam surface.

2. A decompression device as claimed in claim **1** for a multi-cylinder internal combustion engine, further comprising a plurality of bearings wherein at least one bearing is disposed between cylinders for supporting said operating spindle.

3. A decompression device as claimed in claim **2** further comprising:

a spring biassed pin disposed within one of said bearings for supporting said operating spindle, said operating spindle further comprising a recess formed therein for engagement with said spring biassed pin upon said spindle being placed in a position corresponding to commencement of decompression such that said spring biassed pin yields during restoration of said operating spindle to a predetermined original position via rotation of said ratchet wheel.

4. A decompression device as claimed in claim **1** further comprising an end bearing for supporting said operating spindle, and said ratchet wheel being disposed adjacent said end bearing.

5. A decompression device as claimed in claim **4** further comprising:

a spring biassed pin disposed within said end bearing; and

said spindle further comprising a recess formed therein for engagement with said spring biassed pin upon said spindle being placed in a position corresponding to commencement of decompression such that said spring biassed pin yields during restoration of said operating spindle to a predetermined original position via rotation of said ratchet wheel.

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